THE EUGENICS REVIEW.

NATURAL SELECTION.

By Leonard Darwin, Sc.D.

The publication of the theory of Natural Selection in 1858, by Darwin and Wallace resulted in a steadily increasing belief in organic evolution, until at the present day that belief may be said to be universal amongst scientific men. But although it was the idea of natural selection which in fact won the day for evolution, yet towards the end of the last century, this part of Darwin's theories was subject to continuous and increasing attacks. Whether natural selection is now recovering the ground it then lost in the opinion of the scientific world could only be ascertained for certain by a census of opinion amongst scientific men; but in any case, as selection of some kind is the main, if not the only method available for promoting the racial progress of mankind, the final result of this controversy cannot be without interest to all eugenists. I propose, therefore, here to consider some of the underlying causes of these attacks, together with some of the faults actually attributed to the theory of natural selection; and for this purpose, formidable as the task is, I must begin by sketching out in briefest outline what I believe are the views in regard to the struggle for existence now held by those on whose opinion I place most reliance.

Although the Mendelian theory of heredity is fully accepted by me, a word or two concerning the meaning here intended to be conveyed by certain words may not be out of place. The word 'gene' is used to represent any normally independent element of the mechanism of heredity which segregates at each generation; whilst by a mutation is implied any sudden change, great or small, in a gene such as to result in modifications, patent or latent, of the qualities of the organisms to which the gene in question might be transmitted by natural inheritance. As to large mutations, resulting in very marked changes of characters or qualities, these we know from our own observation are rare events in nature, a view which is confirmed by the study of what are known as pure lines. From these facts we may conclude that the sudden appearance of a new variety in nature, such as a butterfly differing in

colour from the parent stock, cannot have been an event of frequent occurrence. Indeed as regards nearly all adaptations of organisms to their surroundings, a natural 'paroxysm' by means of which the descendants of an organism would be suddenly improved to a material extent could only have occurred with such extraordinary rarity that it may be left out of account when studying the processes of evolution. This must be admitted when it is remembered that in order to improve the adaptation of an organism to its surroundings, in nearly all cases many qualities have to be modified, and that if these qualities have to be changed as the result of simultaneous mutations, the improbability of the event is multiplied accordingly; whilst, even if such a highly improbable improvement did make its appearance, it would only show itself for a single generation, because of the segregation and consequent scattering of the altered genes. Except where very few factors—or pairs of genes—are concerned, big mutations may, therefore, here be dismissed; for the result would normally be either a monstrosity, or at all events an organism in which the different functions were so badly co-ordinated as to make survival in the struggle for existence an impossibility.

As to small mutations, on the other hand, the foregoing arguments do not apply, mainly because, being small, they may survive for many generations unless markedly injurious. We know that men differ from each other in height, and, as far as this is due to hereditary differences, it is the result of small mutations which may have occurred either in recent generations or at any time within a period of several thousand years; whilst it has been the pruning effect of natural selection on the one hand, and the very slow but continuous accumulation of mutations on the other, which have determined the existing range of variation in height. In considering what is likely to be the action of natural selection on a differentiated series of this kind, such as is normally exhibited by all qualities in nature, it must be remembered that we are not dealing with simultaneous mutations; and it is the failure to recognise this fact which vitiates many of the mathematical arguments which have at times been brought against the possible evolutionary action of natural selection. *There is no improbability in rare mutations, which first originated at long intervals of time, being simultaneously selected.*

As an example of the fallacious employment of mathematical arguments in this controversy, Prof. Berg's recent book entitled "Nomogenesis" may be quoted, this being in fact a thorough-going attack on the Origin of Species. In discussing the genesis of complicated organs like the eye or the ear we are told that "the probability that all useful variations will simultaneously occur in all the parts is the probability of a miracle" (p. 34). This is doubtless true; but if the mutations on which natural selection could act need not have occurred simultaneously, no such miraculous occurrence need be assumed to have taken place, and this argument falls to the ground, together with a considerable proportion of Prof. Berg's attacks on Darwinism. That eminent statesman, General Smuts, also seems to have been led astray by similar erroneous considerations; for in his recent work on Holism and Evolution (p. 183) he writes as follows:—

"Modifications and variations do not come singly but in complexes, involving many minor and consequential modifications and variations. Are they all individually 'selected' even before they have any individual survival value or strength?"

In order more fully to meet this point as to survival value it is necessary to consider more in detail how selection will act on such a differentiated series. When a graded differentiation exists, obviously one half of the organisms will be above the mean of the group in regard to the quality in question and one half below it; but when considering two qualities in no way correlated, only one quarter of the organisms will be above the mean in regard to both qualities; whilst, for example, only one in 64 will be above the mean in six such qualities. Since nearly all adaptations to environment necessitate the existence of a certain relationship between various organs or qualities in the organism, it follows from what has just been said that as a rule there will exist in every interbreeding group a small percentage which will be superior to the remainder in regard to any small group of qualities which are necessarily co-ordinated for the purposes of adaptation, and in each generation natural selection would promote the survival of this favoured few.*) It is true that in the succeeding generation the genes thus favoured would be scattered throughout the group, the favourable combination thus quickly disappearing; but it is equally true that each such selection would result in a slight increase in the proportion of those genes which, when united in one individual, would produce an organism especially likely to survive in the struggle for life; and that this would lead to a steady but slow increase in the proportion of such individuals appearing in future generations. In other words, the regression to the mean amongst the immediate offspring of any selected group of parents must be regarded more as a wider distribution than as a loss to the race of the superior qualities of those parents. The resulting evolutionary process will be, no doubt, extraordinarily slow, but it will be none the less sure. Moreover, such an advance must inevitably be taking place in nature whenever there exist any individuals superior to the remainder in consequence of the possession of such a favourable combination of genes. And it is especially to be noted that, as the number of those thus favoured in each generation in regard to any one group of qualities is small, a similar advance may be simultaneously in progress with regard to many different groups of qualities, thus resulting in a continuously improved adaptation of the organism to its surroundings in regard to many different organs. As each quality may be dependent on many genes, it follows that when selection is acting simultaneously on several such qualities, the number of the different types of gene which are thus being made to appear with relatively greater or less frequency in any species to a minute extent in each generation may be very great. An evolutionary process under the guidance of natural selection should seldom or never be compared to an army beginning its

* This will be true except when in regard to each one of the qualities the central organism of the series is that which is best adapted to its surroundings in regard to the group of qualities in question.

advance by throwing out a few skirmishers in different directions far to the front, whilst it may nearly always be likened to an invisibly slow forward movement on a wide and uniform front with the leading ranks but little in advance of those following behind.

Having sketched out the way in which it is suggested that natural selection has acted, some of the main criticisms which have been levelled against this theory will now be mentioned. A common attack is based on the erroneous idea that almost infinite variability must be postulated in support of natural selection. For example Prof. Berg declared that Darwin believed that "characters vary in all directions" (p 35); and—unlike most other critics—he supports his asssertion by reference to the following words quoted from the Origin of Species (p. 66), "On the other hand, the ordinary belief that the amount of possible variation is a strictly limited quantity is likewise a simple assumption." Whatever meaning may be attached to these words, it is certain that a belief in the correlation of growth is frequently affirmed in Darwin's writings; and by this is implied that a mutation in one organ will bring with it as a necessary consequence changes in other directions. To hold that one change cannot take place without another change is to declare that such changes are not unlimited in regard to their scope; and Darwin would, I am sure, have declared that mutations are strictly limited in innumerable unknown directions. All that has to be assumed in postalating natural selection to have been an operative evolutionary agency in the past is that the mutations then occurring might have been of such a kind that by their cumulative effects they could have given rise to such organisms as have actually appeared on earth, and this is quite consistent with the existence of great limitations as to the range of possible mutations. If mutations had taken place in all directions, a fish with a screw propeller would have appeared in early geological times.

As to the foregoing quotation from the Origin of Species, by referring to the context it becomes evident that what Darwin intended to affirm was that mutations must be cumulative in their effects; and there is no doubt that such an assumption must be made in support of natural selection. For a long time to come, if not for ever, theories to account for organic evolution should be regarded as provisional hypotheses to be modified in the future if necessary; for what we are still seeking for are the assumptions which best fit in with known facts. When a mutation has taken place we must assume that a further mutation, making a further change in the descendants of the organism in question, is no less probable than was the first mutation; for if there were to be a continual increase in the improbability of mutations occurring, evolution might come to a standstill in time. And the study of fossil remains certainly proves that evolution has gone on by some slow but continuous process for vast periods of time.

We have seen that when adaptations needed the concurrent modification of several parts of the organism, evolution must have taken place very slowly indeed; the reason being that only a very small proportion of the individuals composing each generation could have possessed a balanced superiority in several parts or organs. On the other hand, in the case of a dominant mutation beneficial even if

only affecting one quality of the organism, all the surviving descendants of the mutant organism would exhibit this same superiority and would thus be made more likely to survive and multiply. Not only would the mutation show itself more and more frequently as the generations succeeded each other, but a further advance in consequence of other mutations appearing, as it were, on the top of this first mutation would become a probability. Thus when a single character could have been changed independently in a beneficial manner, evolution might have proceeded with comparative rapidity; whereas the greater the number of parts needing concurrent modification, the slower must have been the process. Taking descent as the basis of classification, two species belonging to the same genus may be compared to brothers, and two genera belonging to the same order to cousins; and if the terms specific and generic differences are merely held to indicate such differences as have actually been used by naturalists in order to classify organisms into species and genera, it follows that as the differentiation on which this classification is based must have occurred since the stocks branched out into separate lines of descent, generic differences must date back earlier than specific differences. Specific differences must, therefore, in many cases have made their appearance with comparative rapidity; and that being the case, we should expect to find that they are often such as can show themselves in one character without concurrent modifications being necessary in other characters; as, for example, differences in external colouring. It is for experts to decide whether, as I suggest, this is actually the case and whether we do not here find some confirmation of the foregoing views in regard to evolutionary methods.

As an illustration of the kind of criticism which results from a failure to realize the way in which natural selection acts we may mention the plea that it is impossible to conceive a Newton, a Beethoven or a Shakespeare as having been produced because of the survival value of the type. On consideration, however, it will be found that the evolution of exceptional types of human beings without definite survival value is not so surprising as it may appear at first sight; though it must be admitted that I am here treading on debatable ground, and that my explanation must be limited to somewhat crude suggestive analogies. If we imagine a box filled with balls of various colours, and that a certain number of them had to be periodically selected by chance, we thus get some idea of the way in which the genes are grouped together to form the individuals of which each generation is composed. To illustrate the formation of the next generation, we must imagine that all those groups of balls which do survive in the evolutionary sense are thrown back into the box, the contents of which are then shaken up together before the next draw is made. Let us begin by assuming that the balls are all either green or red, when each generation will consist of a graded series of groups of balls ranging from all green to all red. Next let us assume that a group composed of an equal number of red and green balls typified the most fit type of individual, whilst groups composed of any excess of red balls and of those composed of the *same* excess of green balls typified individuals *equally* inferior in survival value to the best type. In these circumstances, in each

generation natural selection would keep eliminating an equal number of individuals at each end of the series, with the result that there would be an equal diminution in the number of red and of green balls and consequently no change in the *proportion* of the different coloured balls in the box at the next generation. From this analogy it becomes apparent that, in certain circumstances, natural selection would not tend to produce any one uniform type throughout a species, but would maintain in perpetuity a certain degree of differentiation amongst the organisms composing any freely interbreeding group. Indeed it is my belief that in the absence of all further mutations, what may be described as the normal aim of natural selection would be to produce such a stable differentiated series; and, moreover, that this state of things would facilitate rather than hinder the further adaptation of the organism to its surroundings with the aid of such mutations as would subsequently arise.

To prove my case as to the production of biologically useless men of genius I must, however, make a somewhat different supposition, namely that a group of balls in which there was any excess of red balls was no better and no worse than a group containing an equal number of each colour. In these circumstances natural selection would keep eliminating the inferior groups containing any excess of green balls, whilst producing no such effect on the groups containing an excess of red balls. The inevitable result would be that in time all the green balls would be eliminated, when the selected groups would of necesssity be composed of nothing but red balls; and this in spite of the fact that these pure red groups were in no way superior in survival value to the groups containing some green balls. Thus whether we are looking either to the average of the whole of an interbreeding group or to the very rare combination of qualities such as the greatest geniuses represent, we may judge from this analogy that natural selection might tend to promote the appearance of certain qualities even far beyond the point at which the organism would gain in survival value by their increase; provided that this increase was not in any way actually injurious to them. If the foregoing is in truth what may occur in nature, we need not be surprised at the mathematical, musical and artistic faculties having been developed in man far beyond the point at which they ceased to help him to survive in the struggle for existence; for these are faculties which cannot be regarded as being positively injurious to those who have been thus liberally endowed.

The picture of the evolutionary process which is impressed on many minds by a study of fossil remains is that of an orderly inevitable advance of different organisms, often in parallel directions, towards some predetermined goal, the element of chance being entirely absent. With reference to the orderliness of the process, it may be remarked that if we could look on this earth with the eyes of an inhabitant of Mars, we should in all probability be far more struck with the similarity of the physical surroundings to which many organisms had been exposed for long periods than with the changes which had occurred in the interval, and in the same way it would be the similarity of the organisms themselves in regard to their main physiological features which would strike the Martian eye. Regarding the matter thus,

and remembering that amongst similar organisms there are likely to be similar limitations in regard to the range of possible mutations on account of correlation of growth, should we not expect to find that this slow and complex process of evolutionary adjustment to somewhat similar surroundings would tend to produce somewhat similar changes for vast periods of time in many if not in all of these somewhat similar organisms, the result being parallel modifications even in organisms but distantly related to each other? That such parallel evolutionary processes have often though not always taken place is certain, a process described as rectigradation by Fairfield Osborn and admirably illustrated by his wonderful collections in New York. But do not we find in this fact a confirmation rather than a refutation of the views set forth above concerning the action of natural selection?

Perhaps the most frequent of all the attacks on natural selection are such as are based on the word 'chance.' Darwin made it perfectly clear what he intended to convey by this term when he declared that "this, of course, is a wholly incorrect expression, but it serves to acknowledge plainly our ignorance of the cause of each particular variation." (Origin, p. 106.). If our readers would only take the trouble to substitute for the expression "by chance" some such phrase as "due to unanalysable causes" whenever they meet this form of criticism, they may be surprised to find how often these attacks would break down completely if intended as an answer to Darwin himself.

The word "chance " is no doubt often used in a sense different from that intended by Darwin; that is when the desire is to exclude all idea of purpose, design, or predetermination. When natural selection is attacked because it is held, erroneously as I hold, necessarily to involve an element of chance in this sense, the fundamental question first to be decided should be whether or not like previous conditions always result in like subsequent events. If past experiences do not constitute a sure guide as to future happenings, the man of science and the man of common sense are equally without any reliable guidance in regard either to theory or practice. An orderly sequence of events must be postulated by us as a rule of the universe; and it must be admitted that this postulated orderliness is indistinguishable from that mechanical view of the sequence of events which is condemned by many thoughtful persons. Certain philosophers endeavour to circumvent the to me insoluble mystery which certainly underlies these problems by assuming either that evolution has always proceeded in accordance with fixed laws designed to ensure progress in some definite direction, or that every living cell is endowed with an 'operative factor' or 'creative urge' also making for racial advancement. As to those who thus rely on the idea of law in regard to evolution, they should remember how easy it is "to hide our ignorance under such expressions as the 'plan of creation,' 'unity of design,' etc., and to think that we give an explanation when we only restate a fact." (Origin, p. 422.)

Space forbids a plunge into these endless philosophical controversies; but it does concern us here to note that theories of the universe such as these are at all events useless in helping us to frame a practical eugenic policy. We ought to know why the postulated laws or factors

making for progress failed in regard to both the innumerable species which have disappeared off the face of the earth, and the many civilizations which died out in the past, and that half or nearly half of mankind who have made no advance in comparison with their progenitors. Philosophical ideas concerning design or purpose are of little value in framing practical reforms unless accompanied by answers to these questions; answers which would help us to avoid such catastrophies in the future. We are far from denying the existence of purpose or design in the universe, but we must ask how any such purpose has worked to secure the results intended if we ourselves are to endeavour to promote progress by similar means. And in this quest our knowledge of what has occurred in the past constitutes our only guide; a guide which teaches us that the only method of securing progress in regard to the *hereditary* qualities of man are those indicated by Darwin as having promoted evolution in the past.

Looking at human progress in this purely practical manner, we may note that the artificial production of domestic animals and plants has certainly been purposive: and if we enquire how this purpose has achieved its ends, the answer must be by selection, conscious or unconscious. If there has been purpose in the universe, may we not in like manner assume that selection has been the main agent in promoting progress in all organisms? Of course man can only select from what is before him, and reliance must be placed by him on the effects of mutations. Mutations have, therefore, obviously taken place in the course of several thousand years to such an extent as to permit the production of a greyhound from a wolf, or other wolf-like ancestor; and in regard to evolution in nature, we should consider how much change might possibly be produced by similar means in the course of many hundreds of millions of years. Moreover, the evidence in favour of evolution guided by law seems to us to be as strong or as weak in the case of the greyhound as in that of wild animals; and if the greyhound has made its appearance as the result of some inevitable process of law, the efforts of the breeder, conscious or unconscious, have counted for nothing. As no one will believe that this has been the case, we must accept the appearance of certain qualities in domestic animals as the result of selection, and the effective action of selection in nature may be accepted on precisely similar grounds.

One of the most important questions to be kept in mind when considering the extent to which reliance can be placed on natural selection as an evolutionary agency is whether the first recognizable modification of organisms in past times, which led step by step to useful adaptations in existing organisms, could be proved to have been useless to these ancestral forms. If the appearance in fossil remains of what may be described as useless symtoms of useful organs destined to appear in subsequent geological periods could be demonstrated, no doubt a heavy blow would be dealt against the Darwinian theory. Technical questions are involved in this discussion which I am wholly incapable of dealing with, and all I can say is that our ignorance of what was taking place on earth in past geological periods is so great that it is impossible to rely on any mere expression of opinion as to the uselessness in those bygone days of any structure of which we now have

but imperfect records. It is unreasonable to expect that we shall ever know the way in which all organs in all existing organisms have been evolved in the past; but the ways in which natural selection could have led animals and plants up the evolutionary ladder by steps all of which were useful to them have in our opinion been demonstrated in a sufficient number of cases to make the Darwinian explanation of evolution the one which should still hold the field as by far the most probable hypothesis.*)

No doubt in certain quarters there is now a movement against Darwin's explanation of evolution, even amongst those who would gladly affirm that his work did more than that of any other single individual to establish the fact of evolution in organic life. For me to express a confident belief that the tide will turn again shortly—if it has not turned already—as it did in the case of my father's theory of Coral Reefs, will doubtless carry little weight; but I may perhaps be permitted to suggest why it is that there is so often an ebb and flow of opinion in regard to the scientific beliefs concerning evolution. The most general reason is that it is far easier to attack a previously enunciated theory than to suggest a substitute for it; with the result that critical writings will always be far greater in volume if not in weight than those contributions to science which are constructive. In the second place, the biological experimentalist, after working for a dozen years, is far too apt to hold that he had been able to prove in this short period what *cannot* have taken place in the course of many millions of years. This is merely one more example of the law that all men tend to over-value the importance of their own views and labours, a failing against which even eugenists should be on their guard. The most important of the causes of any set-back to the belief in the efficacy of natural selection has been the failure to realise the way in which the views of Mendel and Darwin are capable of being completely harmonised. Darwin was right in holding that natural selection can only act on individual organisms; but in view of Mendel's discoveries, the modern biologist must hold that natural selection has in each successive generation hardly ever resulted in the *permanent* appearance in the stock of *a few* individuals markedly different from the rest, but has almost always acted by producing exceedingly minute changes in the proportion of the different hereditary ingredients in the stock as a whole in such a manner as only to have produced visible beneficial effects after the process had been in operation for very long periods of time. And here let it be noted in conclusion that this is a kind of evolutionary change which eugenists should by no means leave out of account when framing a practical eugenic policy.

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* I am myself far from denying that difficulties have still to be discussed, the most important being the great similarity of useless structures. These I have indicated, with purely hypothetical explanations, in Organic Evolution, Cambridge Press, 1921.